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Westinghouse Astronuclear Laboratory

CONTROL DRUM BEARING VIBRATION TEST

(EML-85)

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CONTROL DRUM BEARING VIBRATION TEST
(EML-85)

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SUMMARY

A series of vibration tests were run at reactor temperature conditions to determine whether the control drum bearings could withstand the critical axial vibrations that might occur during ground tests of the NRX-A reactors. Additional tests will be required to evaluate the bearings under space operating conditions.

The tests consisted of vibration surveys to determine the critical resonances and one hour dwell tests at each of these resonances to determine whether the bearings would be damaged by exposure to these conditions. The surveys were performed over an envelope of frequency and acceleration conditions which included the most severe vibration conditions expected during reactor testing. A total of 5 hours of dwell tests at accelerations from 2.2 to 20 G's and frequencies from 14 to 1,844 cps were carried out. The vibration inputs during the tests were controlled at the dome end of the simulated outer reflector where the control drum thrust bearing was located.

The friction torque of the bearings was about 15 in.-lb. and remained unchanged throughout the tests. Inspections of the bearings before and after the tests revealed no changes in dimensions or appearance of the balls or races.

This work was performed under EML-85 "Control Drum Bearing Vibration Test".

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INTRODUCTION

Control drum vibration test data obtained in previous control drum and reactor assembly laboratory tests indicated that hammering occurred in the control drum thrust bearings at various excitation frequencies. This hammering was attributed to the larger than normal radial play between the bearing races, which had been incorporated to provide for differential contraction between the races during reactor startup. Since this hammering was felt to be severe enough to damage the bearings during extended reactor testing, it was decided to perform bearing axial vibration tests under conditions which envelope the XE Engine Specification and include provisions for vibration magnification between the reactor pressure vessel and outer reflector sectors. The vibration conditions established for the tests are shown in Figure 1.

TEST DESCRIPTION

Figure 2 shows the cryogenic system for cooling the control drum bearings to the reactor operating temperature, 200°R . Nitrogen gas from a tank trailer was passed through a liquid nitrogen heat exchanger and cooled to about 140°R . After leaving the heat exchanger, the cold gas was blended with gas at room temperature and then admitted to the environmental test chamber.

Figure 3 shows cross sectional views of the control drum test chamber. A test control drum assembly was installed in a titanium barrel simulating an outer reflector sector drum cavity and attached by means of a bellows to the cover of the chamber. Axial displacement of the simulated reflector was accomplished with an electrodynamic shaker. The rod connecting the shaker and control drum entered the chamber through a bellows fitting which prevented gas leakage out of the chamber. The bearing preload spring at the aft end of the control drum was adjusted to apply the design pressure drop load on the drum bearings (550 lb).

Instrumentation of the test components consisted of accelerometers, thermocouples, and a bearing friction torque transducer. Three accelerometers were installed in the system. An axial accelerometer was installed at the forward end of the simulated outer reflector, and axial and lateral accelerometers were attached to the bearing shaft at the forward end of the control drum. The accelerometer at the forward end of the simulated outer reflector was used to control the vibration input conditions. Four thermocouples were used to monitor the temperature of the control drum and bearings during the tests. The location of the accelerometers and thermocouples are shown in Figure 3. To measure the bearing friction torque, a short length of the drum actuating shaft was reduced in cross section and instrumented with strain gages to form a torque transducer. Conax fittings were used to bring the instrumentation leads out of the test chamber and connect them to the recording equipment. Figures 4 and 5 show the test rig and data recording equipment.

All the tests were performed at cryogenic conditions. Before cooling the test rig, the system was purged with dry nitrogen at ambient temperature. The purging was done to remove the water vapor and oxygen from the test chamber. The control drum temperature was monitored continuously at four thermocouple locations. The bearing friction torque was measured at the beginning and end of each test.

The vibration tests consisted of vibration surveys at several acceleration levels and one hour dwells at the resonant frequencies. The sweeping rates during the vibration surveys were 1 and 4 octaves per minute. Accelerometer A-1, shown in Figure 3, was used as the control accelerometer for the input vibration conditions. A tracking filter was added to the vibration control system to eliminate the harmonics of the control accelerometer outputs. The filtering provided a clean sine wave input signal to the shaker.

By performing vibration surveys at various "G" levels, the following critical resonances were established for the design vibration envelope shown in Figure 1.

FREQUENCY (cps)	ACCELERATION (G's)
1844	20
1844	10
733	20
494	20
328	20
14	2.2

One hour dwell tests were performed at each of the above conditions with the exception of the first two. After 30 minutes of testing at 1844 cps and 20 G's, it was necessary to reduce the input to 10 G's in order to maintain control of the shaker system.

RESULTS

The axial accelerometer records obtained during the tests indicated magnification factors of about 3-1/2 to 5 at the resonant frequencies. The maximum lateral accelerations measured were about 10% of the corresponding axial values.

The friction torque of the control drum bearings remained unchanged during the test. The friction torque was 15 in.-lb. at cryogenic conditions and 6 in.-lb. at room temperature.

Dimensional inspections of the bearings before and after the tests and sectioning of the thrust bearing at the conclusion of the tests revealed no wear or damage of the balls or races. A photograph of the sectioned bearing elements is shown in Figure 6. Some fretting of the outside surface of the aft end bearing outer race was observed in the post-test inspections (See Figure 7). However, this condition was not considered important since the bearing was still capable of moving axially in the bearing housing as required at the conclusion of the tests.

CONCLUSIONS

1. The most severe axial vibration conditions expected during reactor ground testing should not cause any change in the control drum bearing friction torque.
2. The present radial play between the bearing inner and outer races does not appear to be large enough to cause the bearing to suffer damage under the most severe expected vibration conditions.
3. Although fretting of the aft end bearing outer periphery was observed (See Figure 7), this condition was not severe enough to prevent relatively free axial motion between the bearing and bearing housing during reactor ground testing.

FIGURE 1
AXIAL VIBRATION TEST CONDITIONS

FIGURE 2
CRYOGENIC GAS SUPPLY SYSTEM

604725J

FIGURE 3

ENVIRONMENTAL TEST CHAMBER

FIGURE 4

TEST RIG AND DATA RECORDING EQUIPMENT

FIGURE 5
CRYOGENIC GAS SUPPLY HEAT EXCHANGER

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FIGURE 6

THRUST BEARING ELEMENTS AFTER TESTING

FIGURE 7
AFT END BEARING AFTER TESTING